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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Bending Glass Sheets Between a Bottom Outline Mold and an Upper Vacuum Press Face

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ABSTRACT

Method and apparatus for shaping one or more glass sheets by supporting the glass sheet(s) on an outline mold having an upwardly facing outline shaping surface constructed and arranged to support the glass sheet's perimeter, heat sagging said glass sheet to conform its periphery to the upwardly facing outline shaping surface and continuing to support said sagged glass sheet on the outline shaping surface while simultaneously engaging the upper major surface of the heat softened glass sheet throughout essentially its entire extent against the downward facing full-faced shaping surface of a vacuum mold to develop a final desired shape onto the glass sheet.

BENDING GLASS SHEETS BETWEEN A BOTTOM OUTLINE MOLD AND AN UPPER VACUUM PRESS FACE

Background of the Invention

1. Field of the Invention

This invention relates to shaping softened glass sheets to non-uniform curved configurations by a combination of preliminary gravity sag bending on a ring-type outline mold and final press bending between the ring-type outline mold and a vertically aligned vacuum mold disposed above the ring-type outline mold.

2a. Technical Considerations

One or a pair of glass sheets is commonly shaped by supporting the sheet or pair on an outline bending mold having a shaping rail with an upper surface whose elevational contours correspond to the final desired shape of the glass sheet slightly within its perimeter. The glass sheet or pair is heated to its heat softened temperature and sags by gravity to enable the perimeter portion of the sheet or pair to assume the desired configuration. This technique is particularly well suited for simultaneously shaping two sheets of glass used subsequently as the inner and outer plies of a conventional laminated automobile windshield.

As glass sheet configurations become more complex and include deeper bend sections, the shaping rails may be segmented and made to pivot from an open position for supporting a flat glass sheet to a closed position for supporting a continuous perimeter portion of a heat softened shaped glass sheet. In the closed position, the shaping rails assume the desired elevational contours of the glass sheet to be shaped slightly inboard of its

perimeter. However, outline bending molds by themselves cannot control the sag of the glass sheet within the supported outline.

Another technique involves bending molds used to shape heat softened glass sheets or doublets to complex configurations by pressing the glass sheets between a pair of aligned full surface press faces. Simultaneous pressurized engagement of a heat softened glass sheet between full-faced press faces may mar the optical properties of the press bent glass sheet.

Upper and lower full surface pressing molds have been used in conjunction with an outline mold wherein a lower mold moves upwardly through the opening within the rail of the outline mold to lift the glass sheet off the outline mold and press the lifted glass sheet against a complementary upper mold. Once the glass sheet is removed from the outline mold, it is difficult to realign the shaped glass onto the outline mold for further movement beyond the pressing stations. Also, when the shaping surface of the lower mold must move through the outline mold, only those portions of the glass within the boundary of the outline mold are pressed. The circumferential area of the glass sheet contacts only the upper press face of the lower mold. As a result, the glass sheets are not pressed to shape out to their peripheral edge.

In order to enlarge the area of the glass that is engaged by the lower pressing mold, outline molds have been modified so that end portions thereof are separated from the central portion of the mold to permit a lower press bending mold with portions of larger size than the outline of the outline mold to lift the glass throughout a greater extent, i.e. the portion that extends beyond the end portion that is normally engaged by an outline mold. Such a feature complicates the fabrication of an outline mold

structure. In addition, it may be difficult to precisely reposition the pressed glass sheet as the lower mold retracts and deposits the glass sheet onto the outline mold.

It is also known to convey heat softened glass sheets on a roller conveyor into a press bending station where the glass sheet is lifted by a lower mold either of a discontinuous ring-type arrangement or a series of shaped slats and shaped either by inertia gravity sagging or by press bending the glass against an upper complementary shaping mold. The upper mold in some of these cases may also be apertured to provide a vacuum for holding the glass after the glass has been shaped, and before the vacuum is terminated, to reposition the bent glass sheet on a glass sheet conveying apparatus which may be additional conveyor rolls or the outline shaping ring. If the bent glass is lowered onto additional conveyor rolls, the shape imparted by press bending may be modified. If the bent glass sheet is lowered onto a shaping ring for further conveyance, it must be aligned perfectly with the outline shaping ring to insure that the glass sheet remains shaped within required tolerances.

It would be advantageous to provide a system of bending glass sheets wherein glass sheets are continuously supported on an outline bending mold for their preliminary shaping by sag bending into contact with the outline bending mold and further supported continuously on the outline bending mold while pressed between the outline bending mold and a full surface vacuum bending mold to impart a final configuration by a combination of full surface suction from above with continuous outline mold support from below so as to minimize the potential problem of marking the major surfaces of the glass sheets when the glass is fully engaged between a pair of full surface pressing molds.

2b. Patents of Interest

U.S. Patent No. 2,131,873 to Goodwillie shapes one or a pair of glass sheets by supporting the glass sheets on an upwardly facing concave shaping surface of a solid lower mold, allowing the glass sheets to sag by gravity to conform to the shaping surface, and pressing the sheets between the lower mold and an upper solid mold having a complementary convex shaping surface. The glass sheets remain on the lower mold throughout the sagging and press bending operation and are engaged throughout their entire extent during the final pressing, which mars the viewing area of the bent glass.

U.S. Patent No. 2,442,242 to Lewis heats flat glass sheets having a straight leading edge while supported on flat strips until the leading edge engages a straight rib. A pair of heated molds having complementary shaping surfaces, sandwich the hot glass to impress a cylindrical shape thereon. The patent is limited in its application to sheets having a straight edge.

U.S. Patent No. 2,570,309 to Black sag bends a glass sheet by heating it while supporting the sheet on an outline ring-type mold to conform to the mold by gravity sagging. The gravity sagged glass sheet is then lifted on a lower solid pressing mold of concave election into pressing engagement against an upper solid pressing mold of complementary shape. The lower mold does not engage and press the outer peripheral areas of the glass sheet against the upper mold. The bent glass sheet is returned to the outline ring-type mold to support the bent glass sheet during cooling.

U.S. Patent Nos. 3,068,672 to Black; 3,408,173 to Leflet; 3,976,462 to Sutara; and 4,687,501 to Reese disclose outline metal molds for shaping a glass sheet of non-rectangular outline to a nonuniform shape by gravity sag bending. Black, Sutara and Reese each further disclose a sectionalized

outline metal mold for the gravity sag bending. No means is provided in any patent to correct the uncontrolled sag in the unsupported regions of the shaped glass sheet.

U.S. Patent No. 3,208,839 to Nordberg press bends as many as three glass sheets to conforming shapes simultaneously using press bending techniques exclusively for the shaping process.

U.S. Patent No. 3,476,540 to Ritter et al. shapes individual glass sheets conveyed on rollers to a shaping station wherein each sheet in turn is lifted sufficiently rapidly by an outline mold consisting of a plurality of shaped bars to shape the glass by the so-called inertia gravity bending method.

U.S. Patent No. 3,554,724 to Ritter et al. combines the inertia gravity bending method of the previous patent with peripheral engagement against a supplemental shaping surface constructed and arranged to be contacted by the upper surface of the glass sheet when the latter is lifted. Neither of these last two patents contain any provision for correcting unwanted sag within the supported margin.

U.S. Patent No. 3,573,889 to McMaster et al. discloses a method of fabricating a shaped laminated windshield comprising press bending horizontally deposed glass sheets individually between upper and lower pressing molds. This process is limited to fabricating laminates of relatively simple gentle curvature containing glass sheets so thin they must be capable of flexing. In addition, the process is inefficient as each glass sheet is shaped individually.

U.S. Patent No. 3,904,460 to Comperatore individually press bends a pair of glass sheets to slightly different configurations as required for the inner and outer glass plies of a curved laminated windshield for automobiles.

The need to press bend the plies separately from each other before laminating provides an operation where efficiency could be improved.

U.S. Patent Nos. 4,260,408, 4,260,409, 4,265,650 and 4,290,796 to Reese et al. and 4,272,275 to Reese disclose the simultaneous shaping of a pair of glass sheets having a non-rectangular outline of nonuniform curvature in plan by combination of gravity sag bending and press bending using full surface, upper and lower shaping molds.

U.S. Patent No. 4,756,735 to Cathers et al. shows a glass sheet shaping method in which glass sheets are positioned on the shaping rail of an outline shaping mold for movement through a heating lehr and subsequently preliminarily sag bent. The mold with the glass sheet supported thereon is positioned between a pair of vertically aligned full surface pressing molds. The molds include selected press surfaces that extend beyond the perimeter of the outline mold. As the lower mold moves upwardly through the outline mold to lift the glass sheet off the outline mold, selected portions of the shaping rail of the outline mold move outwardly to allow the lower mold to pass through the position occupied by the outline mold. The glass is then pressed between the upper and lower full surface pressing molds.

U.S. Patent No. 4,778,507 to Aruga et al. discloses a technique for bending glass sheets heat sagged into their approximate longitudinal shape about a transverse axis over an outline mold and completing the transverse shaping about a longitudinal axis by a full surface pressing mold superimposed over the gravity sagged glass sheet. The dimensions of the full surface mold differs from that of the outline mold so as to minimize the amount of simultaneous engagement of the heat softened glass sheets between the upper full surface pressing mold and the lower bending mold during the final press bending step.

U.S. Patent No. 4,894,080 to Reese et al. discloses an in-lehr press bending operating using pressurized gas. Glass sheets are preliminarily shaped on an outline bending mold and subsequently lifted off the outline mold by a lower full surface press face and into engagement with an upper mold having a peripheral shaping surface. The upper mold also includes a chamber which is subsequently pressurized to urge the glass sheets against the shaping surface of the lower mold.

Summary of the Invention

This invention provides a method and apparatus for shaping glass sheets wherein glass sheets are first sag bent by heat sagging to conform to an outline shaping mold positioned to support the sheet perimeter and provided with complicated transverse bends by subsequently simultaneously engaging the heat softened glass sheet between an upper continuous full-faced vacuum mold while continuously supporting the glass on the outline shaping mold. The glass is continuously supported from below on the outline shaping mold throughout its shaping operation which includes preheating, gravity sag bending on the outline shaping mold to impart the general desired peripheral contour to the glass sheets, press bending the sag bent glass sheet between a full-faced upper vacuum mold and the outline sag bending mold to impart the final desired curvature to the glass sheet without harming the optical properties of the bent glass and cooling the shaped glass sheets. Maintaining the glass sheets in continuous contact with the outline shaping mold throughout the bending and cooling operation avoids the possibility of misalignment caused by non-continuous support on the outline sag bending mold.

Brief Description of the Drawings

Fig. 1, comprising Fig. 1A and Fig. 1B, is a longitudinal side view of a glass sheet bending lehr arrangement in accordance with the present invention. Fig. 1A shows the upstream portion and Fig. 1B shows the downstream portion of the lehr, with certain portions omitted for clarity.

Fig. 2 is a transverse schematic view of a shaping station showing the essential elements of an outline mold and an upper full surface pressing mold with the outline mold depicted in a position vertically spaced from the pressing mold.

Fig. 3 is a sectional view taken along line 3-3 of Fig. 2.

Fig. 4 is a schematic view similar to that of Fig. 2 of a second embodiment of this invention.

Fig. 5 is a partial sectional view similar to Fig. 3 showing an alternate embodiment of the invention.

Detailed Description of the Invention

The present invention relates to shaping heat softened glass sheets but it is understood that the invention may be used to shape any heat softenable sheet material where it is critical that selected edge portions of the sheet must be precisely and accurately shaped. In addition, the invention may be used to shape a single sheet or multiple overlaying sheets. Although not limiting in the present invention, the following discussion will be directed toward shaping two overlaying sheets.

In the drawings, Figs. 1a and 1b depict a heating, shaping and annealing lehr for shaping glass sheets according to the present invention. The lehr extends downstream from a loading zone 20 and includes a heating zone 22 of tunnel type configuration, a gravity bending zone 24 downstream of

the heating zone 22, a press bending or shaping station 26 immediately beyond the gravity bending zone 24, an annealing zone 28 which may include a door 30 beyond the shaping station 26 and a cooling zone 32 in end to end relation in a downstream portion of the lehr. An unloading zone 34 is beyond the cooling zone 32.

Referring to Fig. 2, a pair of stub rolls 36 is shown extending within the side walls (not shown) of the press bending station 26. A mold support carriage 38 comprising a pair of supporting rails 40 which rides over the rolls 36 and supports an outline bending mold 42. Although not limiting in the present invention, in the particular embodiment illustrated in Fig. 3, the mold 42 includes one or more shaping rails 44 combined to form a ring-like member conforming in elevation and plan outline to the peripheral shape of glass sheets G supported on the upper edge surface of shaping rails 44 for gravity sag bending slightly within the marginal perimeter of the glass sheets G. A plurality of vertically extending uprights 46 interconnect the mold support carriage 38 with the outline mold 42 so that the outline mold is spaced above the carriage 38.

The press bending station 26 of Figs. 2 and 3 also contains an upper vacuum press bending mold 48 having a downward facing shaping surface 50 with a peripheral shape complementing the shape of the outline sag bending mold 42. Shaping surface 50 is curved as depicted in Fig. 3 to conform to the final configuration to be imparted to the glass sheets G. A piston 52 is attached to mold support carriage 38 to engage and lift a plate 54 affixed to a cross beam on mold support carriage 38 so that the latter moves vertically parallel to a fixed vertical axis that preferably intersects the geometric center of the mold support carriage 38 and press bending mold 48 when the

former is properly positioned within press bending station 26. The details of aligning the outline mold 42 and the mold support carriage 38 within press bending station 26 are well known in the art and details thereof can be obtained by reference to U.S. Patent No. 4,756,735 to Cathers et al., which is incorporated herein by reference, and particularly at column 5, line 32 to column 6, line 45.

In operation, a plurality of mold supporting carriages 38 each supporting a pair of glass sheets G positioned on shaping rails 44 of mold 42 are conveyed along the length of the shaping and annealing lehr. One carriage at a time comes to a stop and is positioned within shaping station 26 so that the mold 42 is aligned with the upper vacuum mold 48 as depicted in Figs. 2 and 3. By the time each outline mold 42 arrives at the press bending station 26, its supported glass sheets G have been subjected to elevated temperatures for sufficient time to sag bend and generally conform their periphery to the elevational contours of shaping rail 44.

Once positioned within shaping station 26, the piston 52 lifts the mold support carriage 38 into a position wherein the upper heat softened glass sheet, previously sag bent to conform to the upper shaping surface of the shaping rail 44 of outline sag bending mold 42, engages the downward facing shaping surface 50 of upper vacuum mold 48. The periphery of the heat softened glass sheets is sealed against the shaping rail 44 of the outline sag bending mold 42 so that when a vacuum is supplied through the upper vacuum mold 48, the glass sheets develop the configuration of the downward facing shaping surface 50 by differential pressure due to subatmospheric pressure applied along shaping surface 50. More particularly, because the upper mold 48 and shaping rails 44 seal the periphery of the heat softened glass sheets

G, as vacuum is drawn through the upper mold 48 via outlet 56, the upper glass sheet will be drawn into contact with its shaping surface 50. As the upper glass sheet tries to separate from the lower glass sheet, a partial vacuum between the sheets is formed which results in the lower glass sheet moving along with the upper glass sheet. As a result, both sheets are shaped by the vacuum mold 48.

Vacuum mold 48 is made of a ceramic material, as shown in Fig. 3 or is metal, e.g. cast iron, stainless steel, or mechanite, and is provided with a pattern of holes having a diameter of 3/16 inch on 2 inch centers (0.48 cm on 5.08 cm centers). Vacuum has been supplied at levels ranging from 8 inches to 30 inches (20.32 cm to 76.2 cm) of water column, for a vacuum hold time of 2 to 30 seconds with both glass sheets conforming to the transverse shape of the downward facing shaping surface 50 of upper vacuum mold 48.

In order to further assure that the outline mold 42 is properly aligned with the upper vacuum mold 48, an alignment device 58 may be provided. Although not limiting in the present invention, in the particular embodiment illustrated in Figs. 2 and 3, device 58 is a rod and cone assembly which includes a downwardly extending rod member 60 attached to the support 62 for upper mold 48 and a cone receiving member 64 mounted on the mold support carriage 38. Cone member 64 is positioned to receive rod member 60 as carriage 38 is lifted to press the glass sheets G against upper mold 48. The device 58 accurately aligns the carriage 38 relative to the upper mold 48 prior to its engagement with the glass sheets.

While the outline sag bending mold 66 is lifted by piston 52 in the embodiment depicted in Figs. 2 and 3 and held for the time intervals at the vacuum range described previously, it is also possible to have the sag bending

mold 42 and its supporting mold support carriage 38 remain in a vertically stationary position while lowering upper press bending mold 48 against the upper major surface of the upper glass sheet supported on the outline mold 42 as depicted in Fig. 4. In either embodiment, outline mold 42 continuously engages the glass sheet slightly inboard of the glass sheet edge on the shaping rail 44 of the outline sag bending mold 42 for a sufficient time to allow the vacuum mold 48 to provide sufficient vacuum to ensure the imposition of its transverse shape as depicted in Fig. 3 without causing the sheets to separate when bent as a pair.

It is understood that the time and vacuum level necessary to ensure that the glass sheets do not separate from one another during the pressing and vacuum shaping of glass sheets G when the pair is pressed between the upper vacuum mold 48 and the lower outline mold 66 varies depending on the glass sheet thickness and bending temperature.

After completion of the pressing and vacuuming shaping, the vacuum is terminated and the vacuum mold 48 and outline mold 42 are separated, either by lowering the outline mold 42 onto the stub rolls 36 (following the method of Figs. 2 and 3) or raising the upper vacuum mold 48 (following the method of Fig. 4), while continuing to support the glass sheets on outline mold 42. The shaped glass sheets remain supported on rails 44 of mold 42 while the mold support carriage 38 moves into the annealing zone 28 where the glass sheets G are cooled at a desired cycle of cooling to develop the desired anneal in the bent glass sheets.

Although the bending mold 42 as previously discussed include rails 44 that support the glass sheets G on the rail edge inboard the sheet periphery, other types of rail configurations may be used. Referring to Fig. 5, rails 144 of bending mold 142 have an L-shaped configuration so that

the marginal edge portion 100 of the glass sheets G are fully supported on the upper extended surface 102 of rails 144 about the glass sheet periphery. This type of rail shape has been known to reduce marking of the glass sheets that sometimes occurs when the sheets are supported inboard of the sheet periphery on the edge of a shaping rail as shown in Fig. 3. It should be noted that with an L-shaped rail configuration, during the final shaping operation, the entire periphery of the glass sheets G are pressed between the upper vacuum mold 48 and the rail 144 to more positively shape the marginal edge portion 100 of the glass sheets G.

It is understood that the schematic illustrations of this invention depicted in Figs. 2, 3 and 4 provide sufficient basis for understanding the principles of this invention and that additional structural details may be found in U.S. Patent 4,756,735 to Cathers et al. However, the present apparatus omits a full-face lower pressing mold, the lower mold pressing actuating means that lifts and lowers the lower pressing mold and the expanding outline mold arrangement which allows the lower mold to pass through the outline mold, all of which are disclosed in the Cathers et al. patent.

The downward facing shaping surface 50 of upper vacuum mold 48 is large enough to be coextensive with the area and outline of the glass sheets G mounted on the outline sag bending mold 42. This enables the glass sheets G to be engaged simultaneously between the rails 44 of outline mold 42 at a slight distance inward of the perimeter of the glass sheets G on their bottom surface and throughout their entire extent at their upper surface by upper vacuum mold 48. This gives the glass sheets G a shape by suction without inducing pad marks on the lower major surface of the glass that results from simultaneous pressurized engagement of the entire glass sheet surface from

above and below. In addition, it is believed that the pad marking on the upper major of the glass sheet will be less when the glass is shaped by the vacuum as compared to pressing the glass between a pair of full surface bending molds. The combination of full surface engagement from above and perimeter engagement only from below imparts better optical properties in the bent glass than full surface engagement of the outwardly facing major surfaces of the glass sheets.

It is understood that the press bending mold 48 may be provided with a cover of woven fiber glass or other material that insulates the upper surface of the glass G from direct contact with the surface 50 of bending mold 48 and also provides means for diffusing the flow of vacuum into the apertures arranged throughout the entire extent of the upper vacuum mold 48.

It is also understood that when the outline sag bending mold 42 and upper press bending mold 48 are separated from one another, it may be desired to reverse the flow of vacuum and pressurize the interface between the downwardly facing shaping surface 50 and the upper surface of the glass sheets G momentarily to help release the upper surface of the glass from contact with the vacuum mold 48 and retain the intimate contact between the shaped glass and the outline sag bending mold 42 so that the glass does not become displaced relative to its outline bending rails 44 that support the glass around its perimeter portion.

The present invention may also be used to impart reverse, or "S shape," curvatures in the central portions of the glass sheets. More particularly, a pan mold (not shown) as disclosed in U.S. Patent No. 4,979,977 to Frank et al. which teachings are hereby incorporated by reference, may be positioned within the rails 44 of the bending mold 42 to preliminarily form

the reverse curve in the glass sheets. Press mold 48, being provided with a shaping surface 50 that includes the final desired glass sheet curvature, including the reverse curvature, would then be used to shape the glass sheets in a manner as discussed earlier.

The form of the invention shown and described in this disclosure represents an illustrative embodiment thereof and a variation thereof. It is understood that various changes may be made without departing from the teachings of this invention defined by the claimed subject matter which follows:

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARED DEFINED AS FOLLOWS:

1. An apparatus for shaping heat softened sheet material to a predetermined shape comprising:

an upper vacuum mold having a downwardly facing full surface shaping surface contoured to generally correspond to the final desired curvature of said sheet to be shaped;

an outline shaping mold having an upwardly facing peripheral shaping surface generally corresponding to the final desired contour of the periphery of the sheet to be shaped and complimenting a corresponding portion of said shaping surface of said vacuum mold;

means to move said first and second molds relative to each other to engage said sheet between said first and second molds; and

means to apply a vacuum along said vacuum mold shaping surface to urge said sheet toward said vacuum mold shaping surface while said sheet is engaged between said molds.

2. The apparatus as in Claim 1 wherein moving means includes means to lift said outline shaping mold with said glass sheet supported thereon toward said vacuum mold shaping surface.

3. The apparatus as in Claim 1 wherein said moving means includes means to lower said vacuum mold shaping surface toward said outline shaping mold.

4. The apparatus as in Claim 1 wherein said outline shaping mold comprises a pair of mold sections pivotally interconnected for movement between a spaced position for supporting flat glass and a closed position for supporting a bent sheet of glass.

5. The apparatus as in Claim 1 wherein said applying means includes means to draw said vacuum through at least a portion of said upper mold.

6. The apparatus as in Claim 5 wherein said drawing means includes a plurality of passages extending through at least a portion of said vacuum mold, said passages terminating along said vacuum mold shaping surface.

7. The apparatus as in claim 5 wherein said outline mold supports said sheet to be shaped slightly inboard of the sheet's perimeter.

8. The apparatus as in claim 5 wherein said outline mold supports the marginal edge portion of said sheets.

9. A method of shaping heat softened sheet material comprising:

supporting said heat softened sheet material on an outline mold having a shaping rail with plan outline generally corresponding to the shape of said sheet and having an upper shaping surface corresponding to the final desired elevational contour of said sheet's perimeter;

allowing said sheet to sag by gravity to substantially conform said sheet perimeter to the contour of said shaping rail;

positioning said sheet and outline mold relative to a vacuum mold having a full surface press face with a surface contour corresponding to the final desired curvature of said sheet such that said shaping rail is aligned with a portion of said vacuum mold press face generally complementing said shaping surface of said shaping rail;

moving said molds relative to each other to press said sheet perimeter between said rail shaping surface and said vacuum mold press face; and

applying a vacuum along said vacuum mold press face to urge said sheet against said press face while said sheet perimeter is pressed between said press face and rail shaping surfaces.

10. The method as in Claim 9 wherein said moving step seals said sheet perimeter against said vacuum mold press face.

11. A method as in Claim 10 wherein said moving step includes lifting said outline mold with said sheet supported thereon into engagement with said vacuum mold shaping surface.

12. A method as in Claim 10 wherein said moving step includes lowering said vacuum mold into engagement with said sheet while said sheet is supported on said shaping rail.

13. The method as in Claim 10 wherein a second heat softened glass sheet is shaped simultaneously with said glass sheet and further including the steps of positioning said second glass sheet over said glass sheet in vertical alignment thereover such that an upper major surface of said second glass sheet engages said vacuum mold press face during said moving step while a lower major surface of said first named glass sheet is supported on said rail shaping surface.

14. The method as in claim 10 wherein said supporting step includes providing shaping rails with an extended shaping surface that generally complements a corresponding portion of said vacuum mold press face such that said sheet's marginal edge portion is fully supported on said extended surface.

15. The method as in Claim 14 wherein said moving step further includes the step of pressing said marginal edge between said extended surface of said rail and said corresponding portion of said vacuum mold press face.

16. A method of shaping a glass sheet comprising mounting a flat glass sheet over an upwardly facing outline shaping surface of elevational and outline contour constructed and arranged to support said glass sheet after heat sagging by gravity about the sheet's perimeter, heat sagging said glass sheet to conform said sheet perimeter in shape to said upwardly facing outline shaping surface and to seal its downwardly facing major surface against said upwardly facing outline shaping surface, moving said conformed glass sheet to a position spaced below a full-faced vacuum mold having a downwardly facing shaping surface of a final desired configuration, reducing the spacing between said outline shaping surface and said full-faced vacuum mold until the upper major surface of said heat sagged glass sheet simultaneously engages said downwardly facing full-faced shaping surface while the lower major surface of said glass sheet continues to seal against said upwardly facing outline shaping surface, applying suction through said full-faced vacuum mold to said simultaneously engaged heat sagged glass sheet until said sheet conforms to the shape of said downwardly facing full-faced shaping surface, discontinuing said suction and separating said vacuum mold shaping surface from said upper

major surface of said glass sheet while maintaining support of said glass sheet by said outline shaping surface continuously throughout said method.

17. The invention or inventions substantially as herein described and with reference to any of the preceding claims.

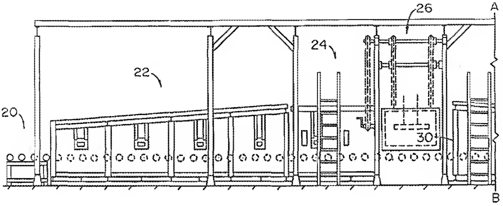

FIG. 1a

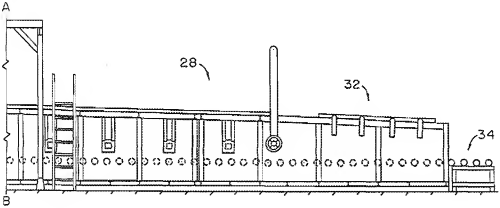

FIG. 1b

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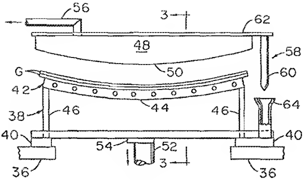

FIG.2

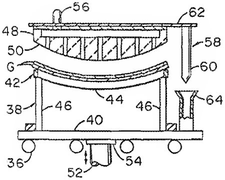

FIG.3

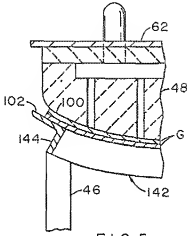

FIG.5

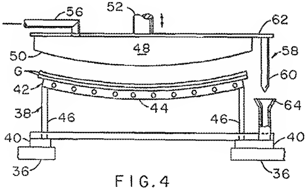

FIG.4

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